Positron Production for the ILC

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Contributor Institutions/ Today's Topics

BNL,LLNL, SLAC, U.C. Berkeley

LC Positron Production Issues

Topics for Study

E166

BNL Damage Tests

ILC Damage Studies

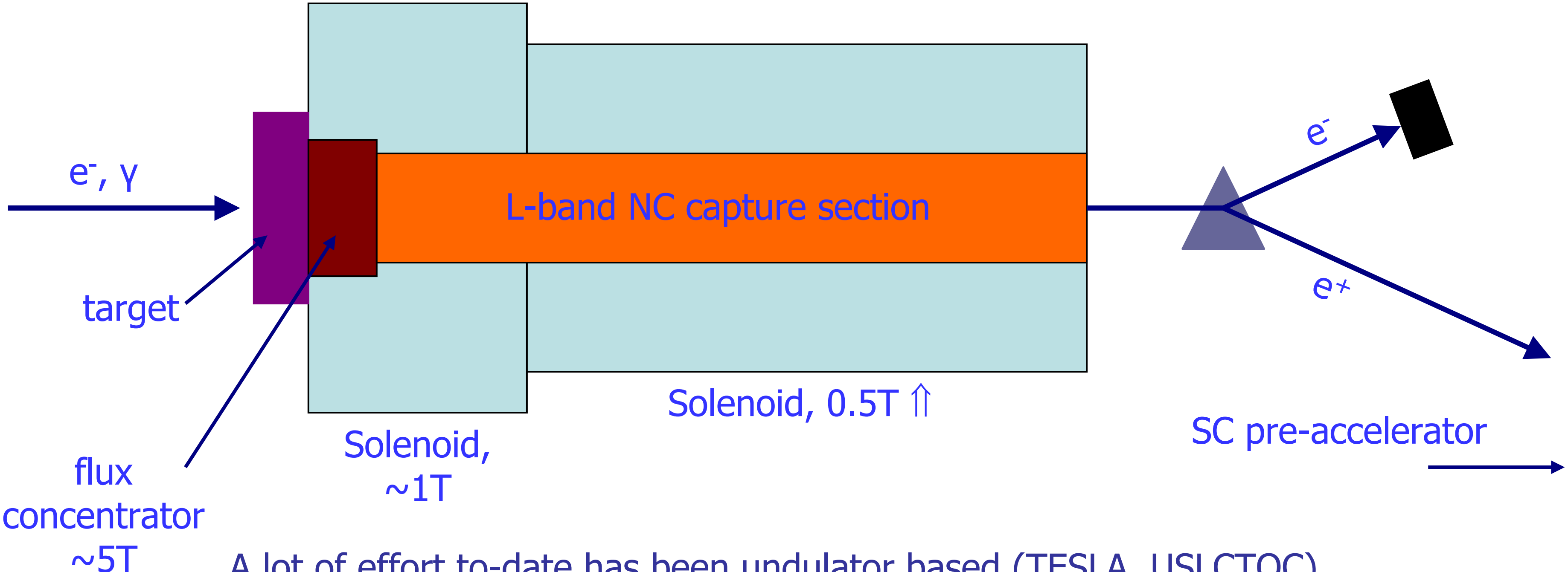
CDR/TDR Work

Positron Injection
(from D.C. Schultz)

SLAC
LLNL
UCB
BNL
Cornell (U)
Daresbury (U)
DESY Z(?) (U)

A generic positron source.

How many are needed?



A lot of effort to-date has been undulator based (TESLA, USLCTOC).

Conventional source feasibility is an important topic.

Parameters/Specifications(?)

(1 ms bunch trains, 2820 bunches/train, 5 trains/s)

Bunch trains at 5hz

2820 bunches per train, upgradeable to 4886 (?)

337 ns bunch spacing in and out of the DR's

2×10^{10} e^+ per bunch out of the DR's

Polarization (perhaps) ~60%

Yield into the Capture Acceptance Needs to be Determined through Simulation

Topics for Study

Basic Capture Yield Calculations (AMD, rf gradient, focusing optics, capture aperture(6-D)) [Capture yield is on the order of 1: e- to e+, e- to γ to e+]

Energy Deposition and Stress [50-200 J/g: W-Re, Ti-alloy]

Radiation Damage Threshold [~1 dpa]

Candidate Target Material Selection and Testing [WReHf, TiAlV]

Average Power Removal [~250 kW drive beams]

Target Station Layout [multiple target stations operating in parallel]

Removal and Replacement Scenarios [light bulbs turn black]

Infrastructure (remote handling, equipment shielding)

Undulator Parameters/Undulator Design and/or Conv. Drive Beam Energy

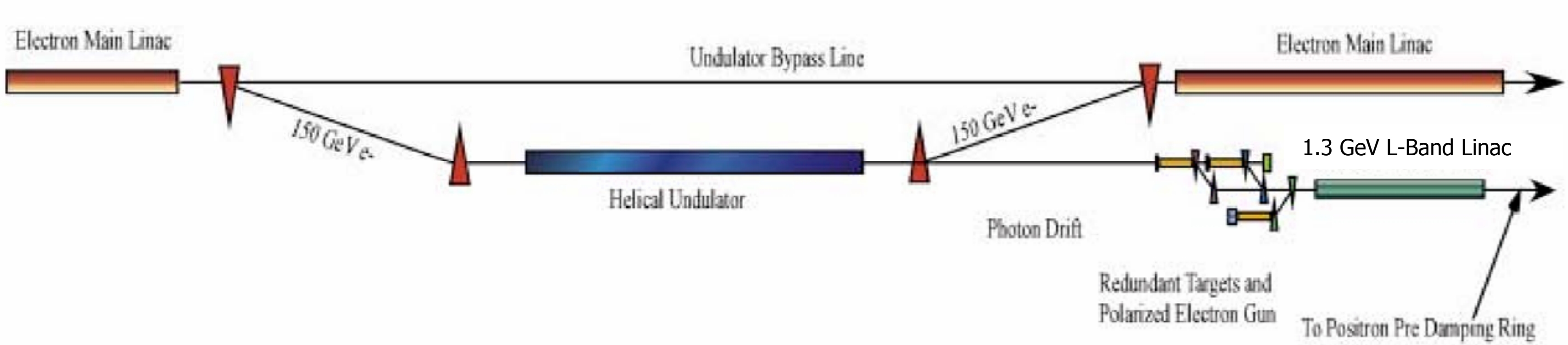
Undulator Insertion Bandpass and Machine Protection

Civil Facility Specifications

Commissioning, Operations, Availability

Polarized positrons for the ILC

- The >150 GeV electron beam is used for the production of polarized positrons
- Electron beam passes a 200m helical undulator (K=1, λ=1 cm, 50% capture overhead)
- After conversion, the positrons are captured and accelerated to the DR energy
- The positrons collide with a subsequent electron bunch train



Undulator Source Attributes and Issues

~ 60% Positron Polarization

Fixed Drive Beam Energy

Use of High Strength, Low-Z Conversion Target Material (TiAlV)

Single Target Station to Produce Full Bunch Train

Reduced Neutron Production Results in Lower Radiation Damage to Target and Surrounding Environment

Requires a High Energy (~150 GeV) e- Drive Beam

Concern of Total Machine Availability if Use Collision Electrons for Positron Production

E166 Collaboration

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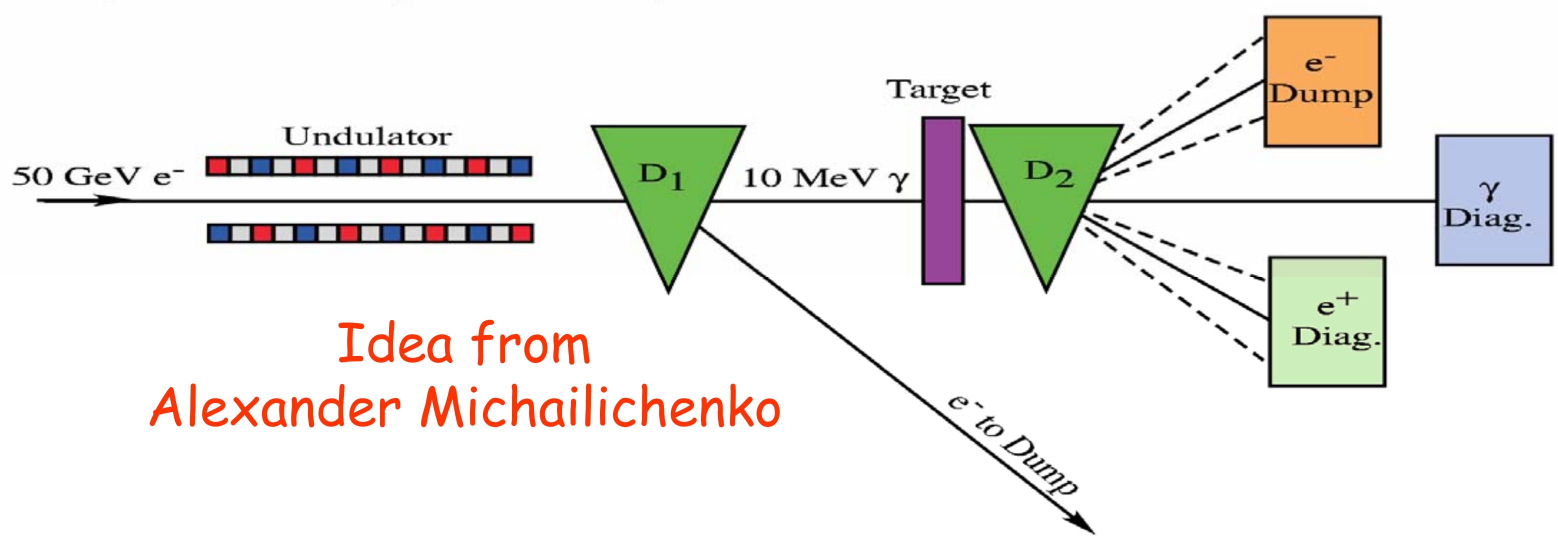
About 45+2 members from 16+1 institutions from all three regions (Asia, Europe, the Americas, and Daresbury)

John Sheppard, Kirk McDonald (co-spokesmen)

Overview of E166

- Demonstration experiment for production of polarized e^+
- FFTB at SLAC with 50 GeV, 10^{10} e^-/pulse , 30 Hz
- 1 m long helical undulator produces circular polarized synchrotron radiation 0-10 MeV (K=0.17, λ=2.5 mm, 0.4 γ/e^-)
- Conversion of photons to positrons in 0.5 rad Ti-target
- Measurement of polarization of positrons by Compton transmission method



Idea from Alexander Michailichenko

E166 Experiment

E-166 is a demonstration of undulator-based production of polarized positrons for linear colliders:

- Photons are produced in the same energy range and polarization characteristics as for a linear collider;

-The same target thickness and material are used as in the linear collider;

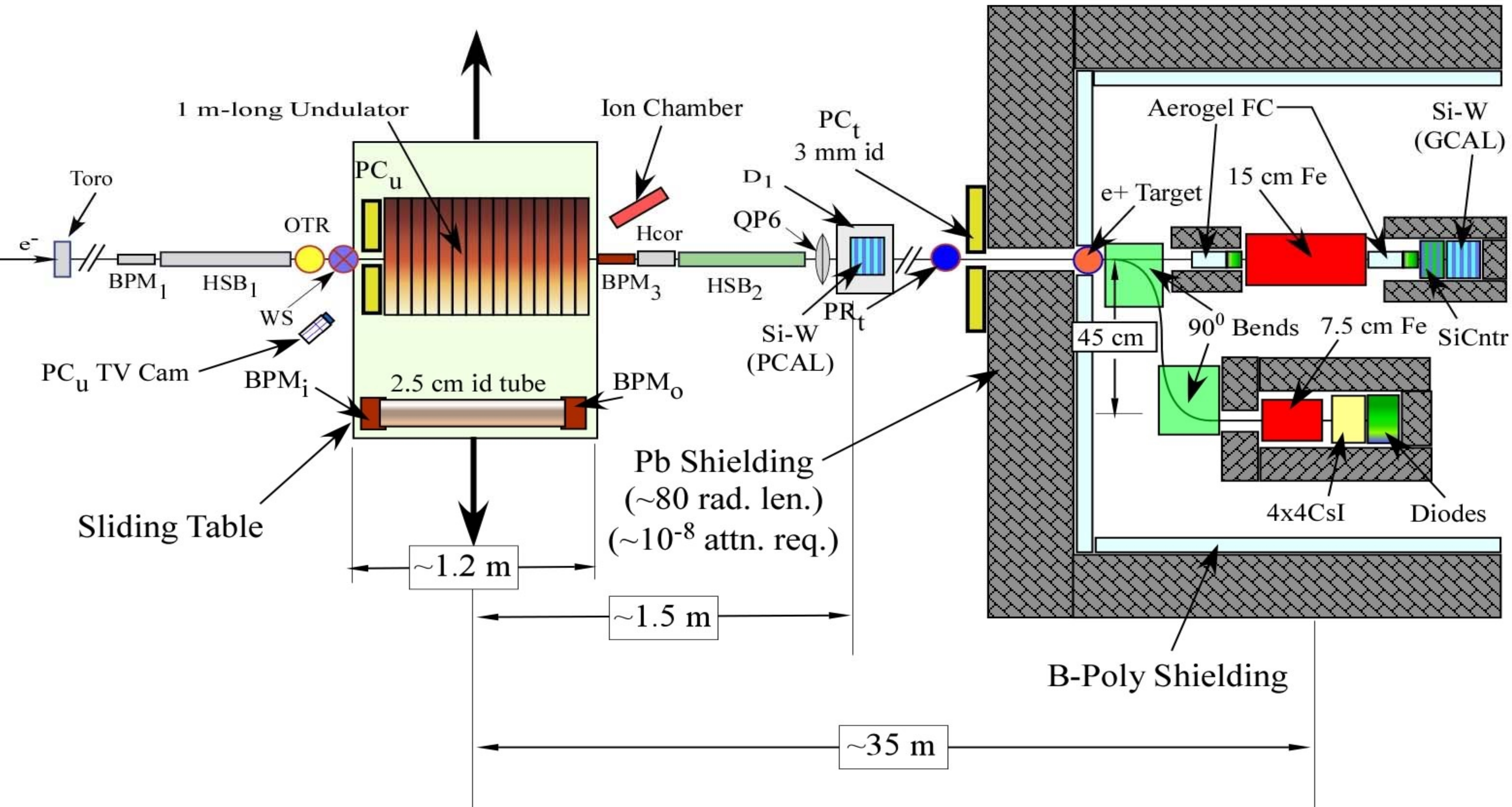
-The polarization of the produced positrons is expected to be in the same range as in a linear collider.

-The simulation tools are the same as those being used to design the polarized positron system for a linear collider.

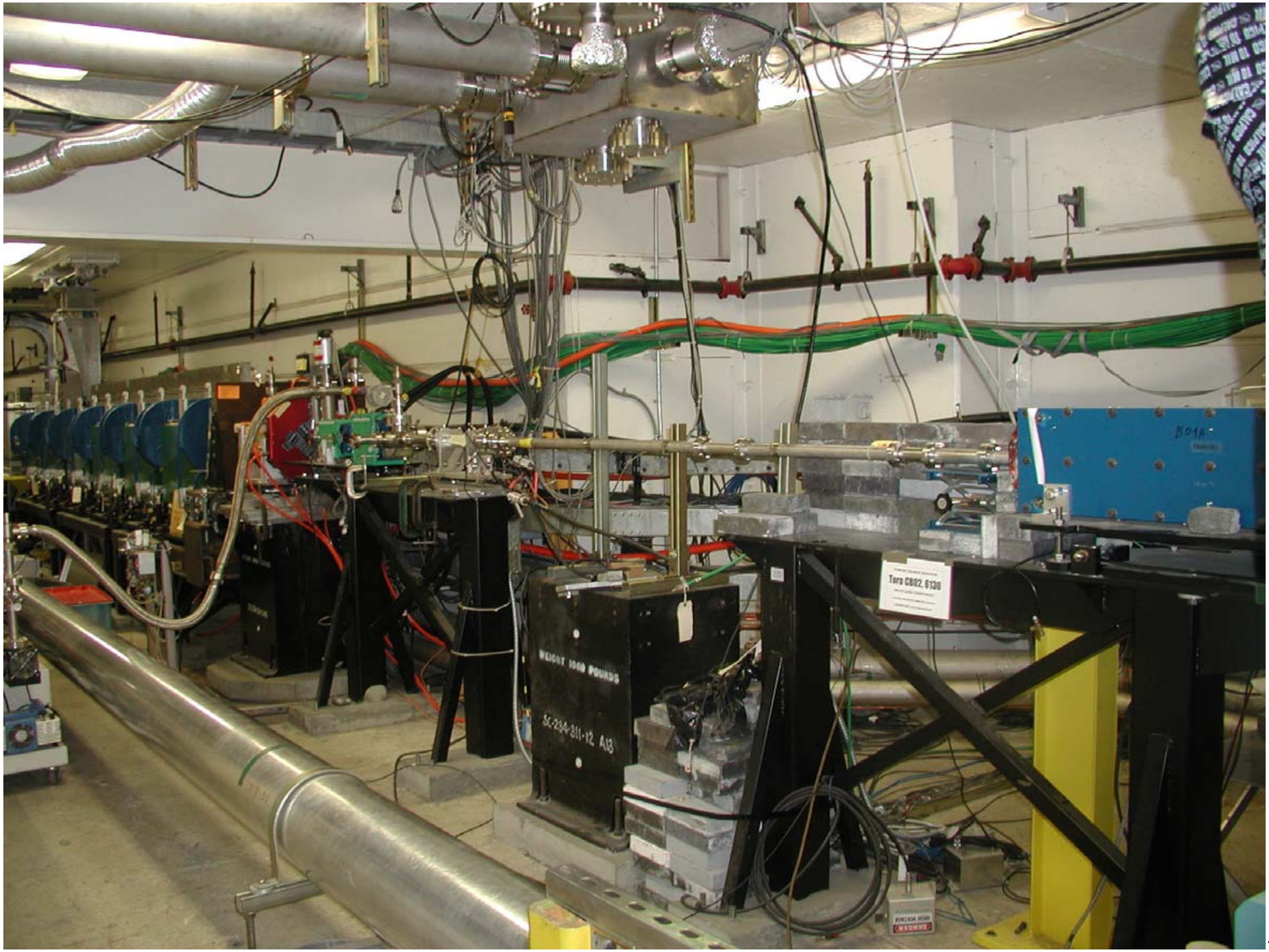
- However, the intensity per pulse is low by a factor of 2000.

E166 Equipment

E-166 : Plan View, r2
(50 GeV)



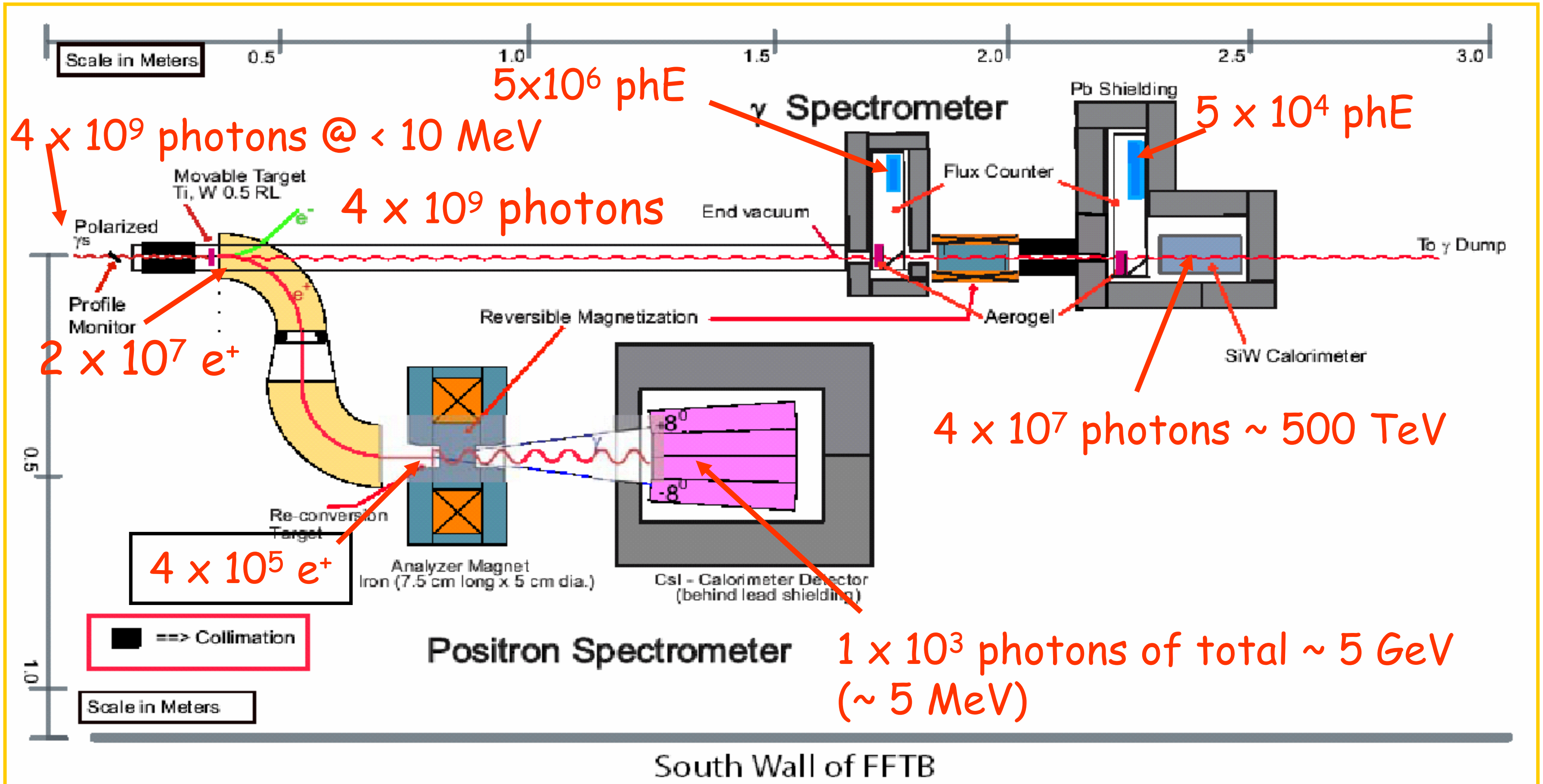
E166 Undulator Area: SLAC FFTB



Spectrometer Area: SLAC FFTB

Beam Intensities & Energies

- 10^{10} electrons/bunch @ 50GeV into the undulator



E166 Status

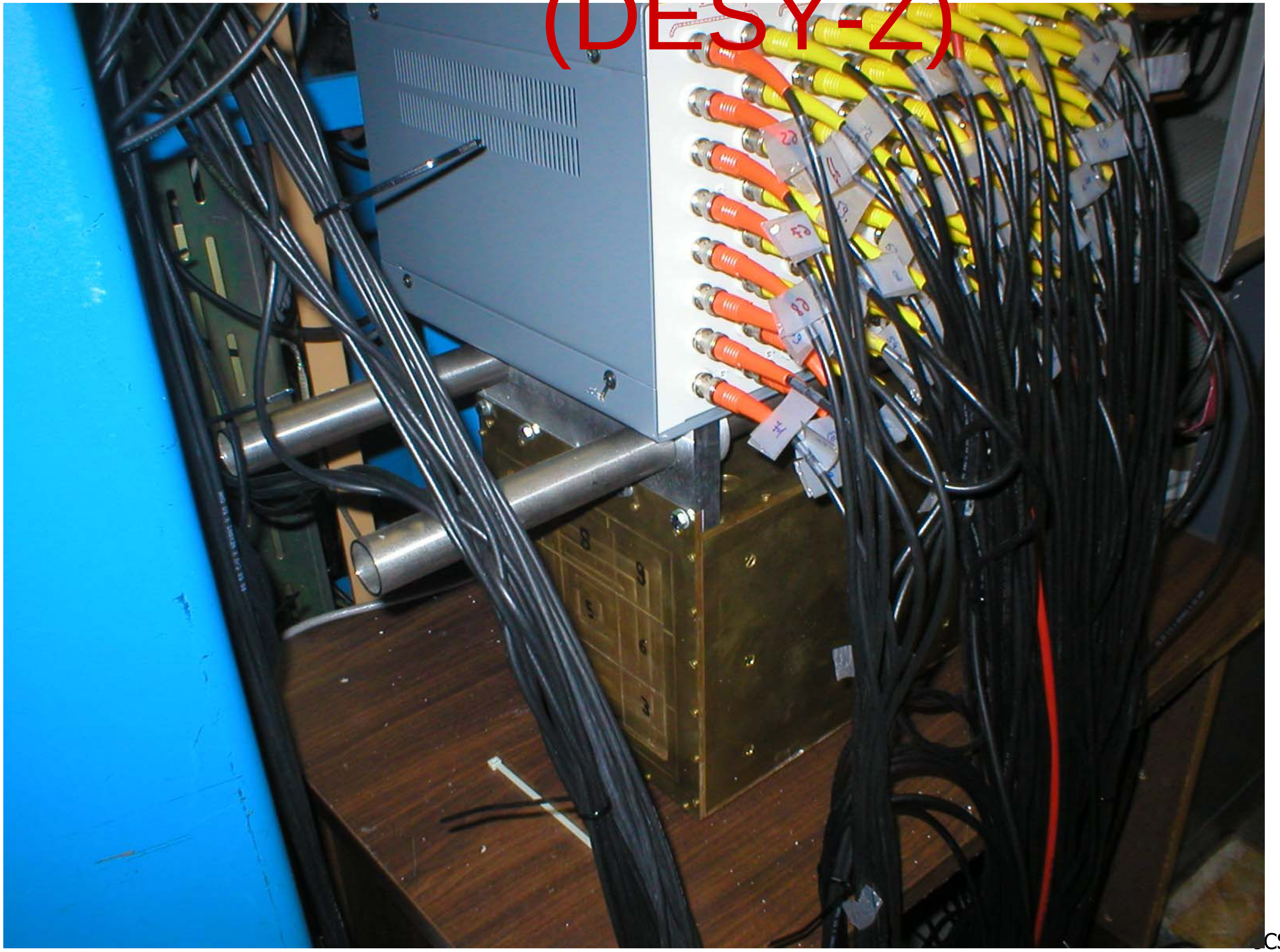
E166 was scheduled to run in October, 2004 and again in January, 2005. The October run has been terminated, will resume in January, 2005 (likely delayed).

All equipment is at SLAC, final assembly of undulator shuttle in in progress; will complete installation by end of month (???dilation of schedule due to work slow down at SLAC in response to accident investigation???)

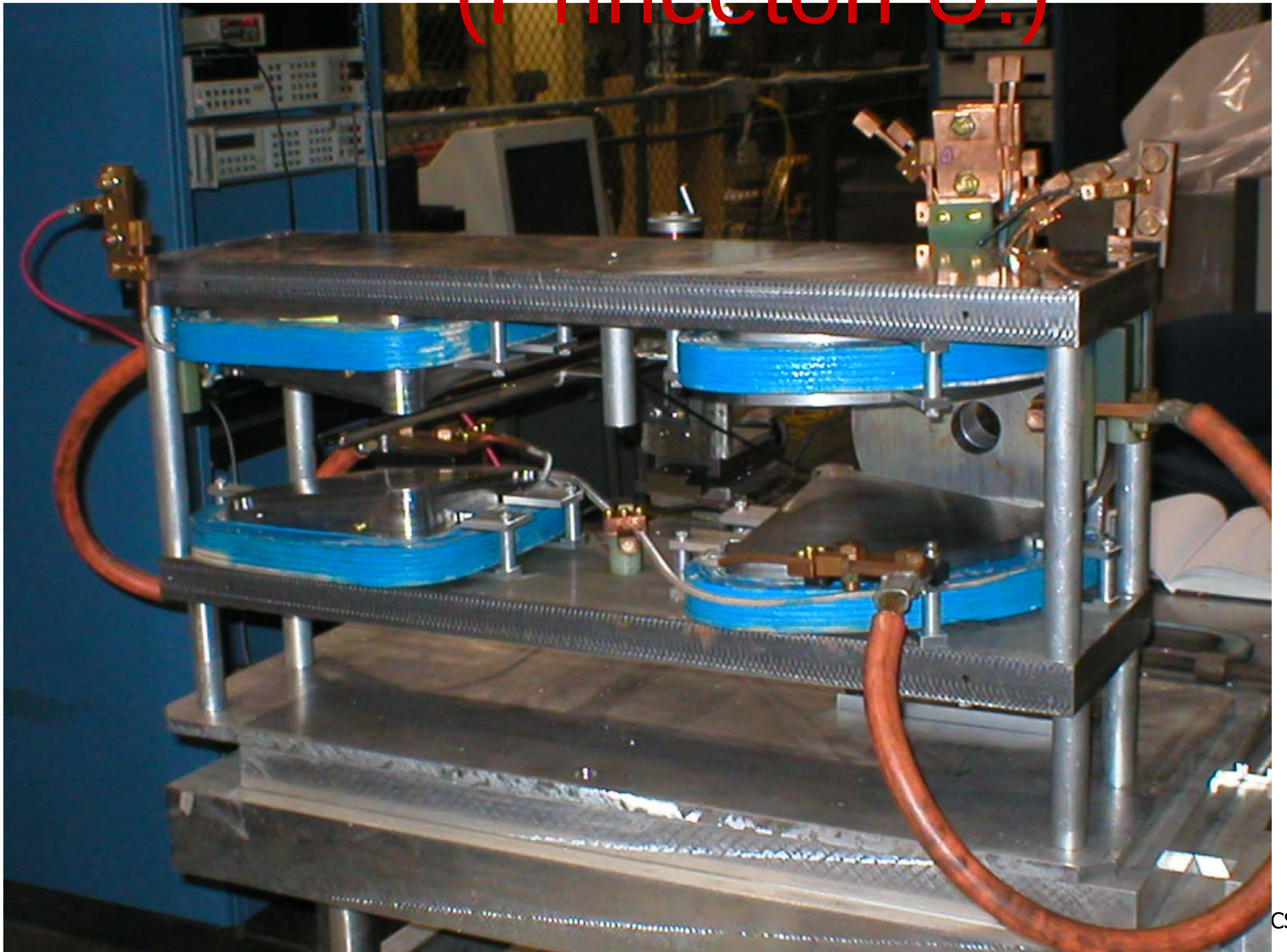
Initial operation (6.5 shifts at 28.5 GeV) demonstrates quiet detector noise environment (beam dump and streaming from up-beam scrapping); 42 micron rms spot; instrumentation, detectors, DAQ commissioned; preliminary data analysis package has been exercised.

E166 Status: Fe Absorbers (DESY-HH)

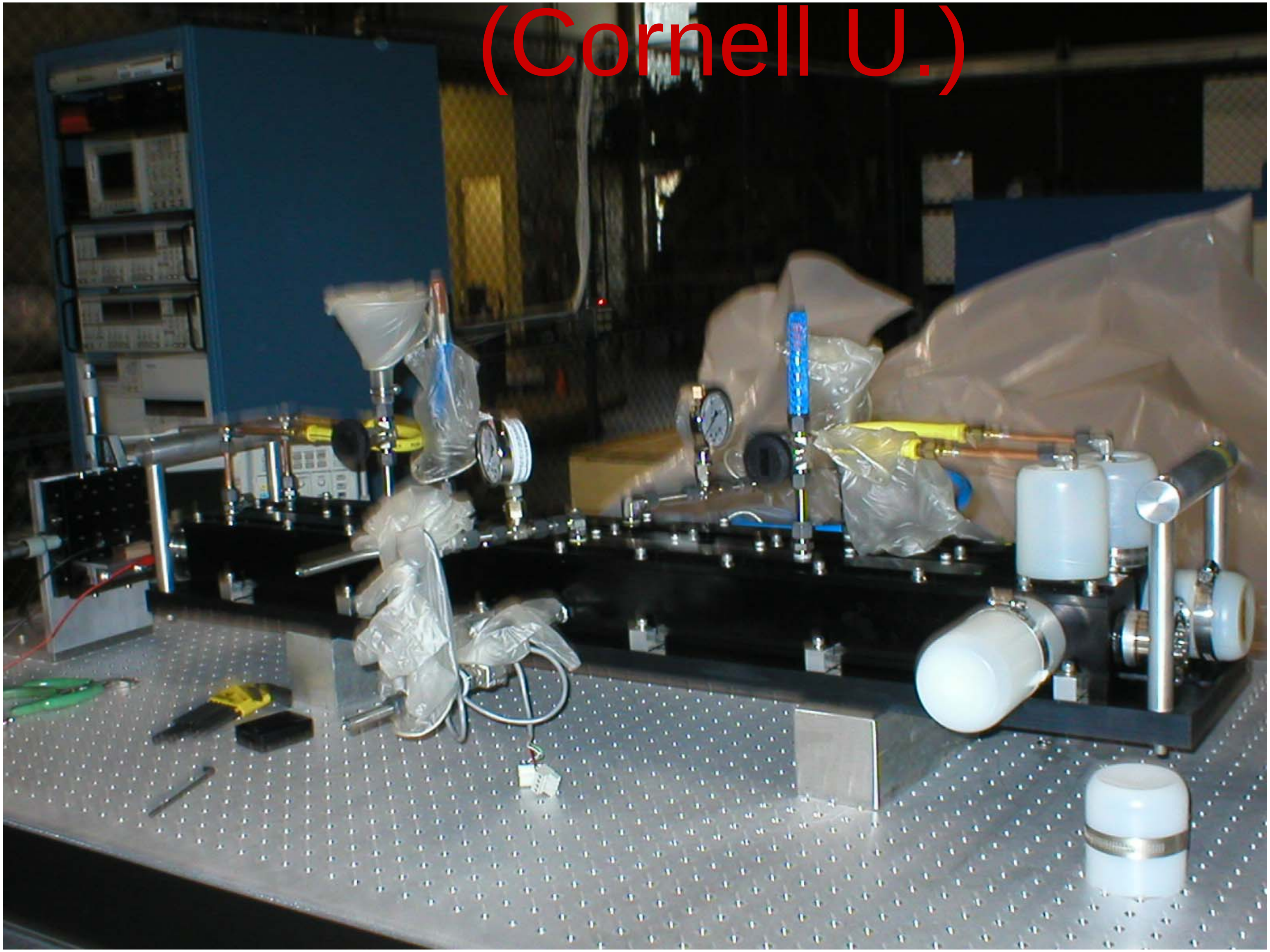
E166 Status: CsI (DESY-Z)



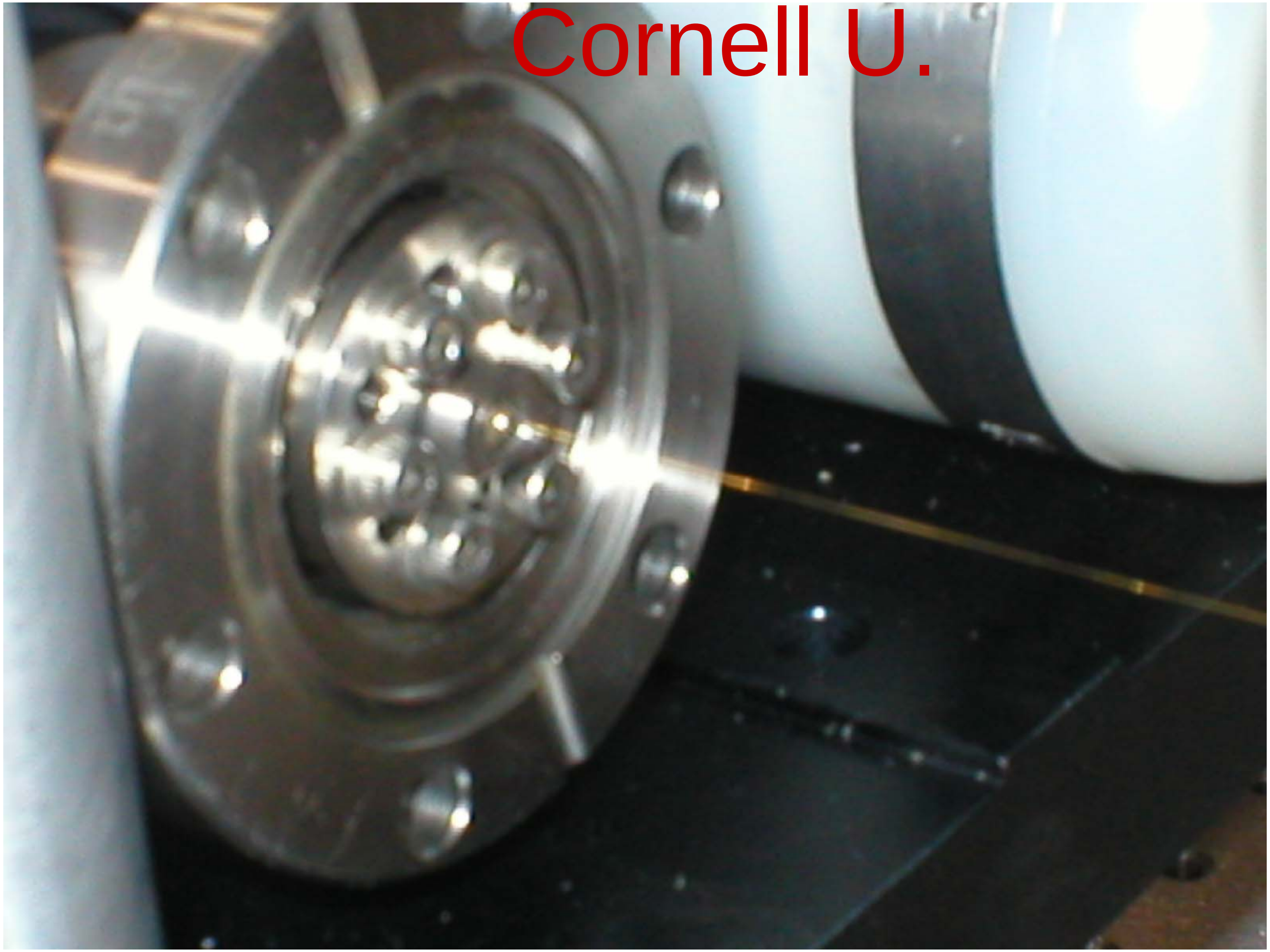
E166 Status: Spectrometer (Princeton U.)



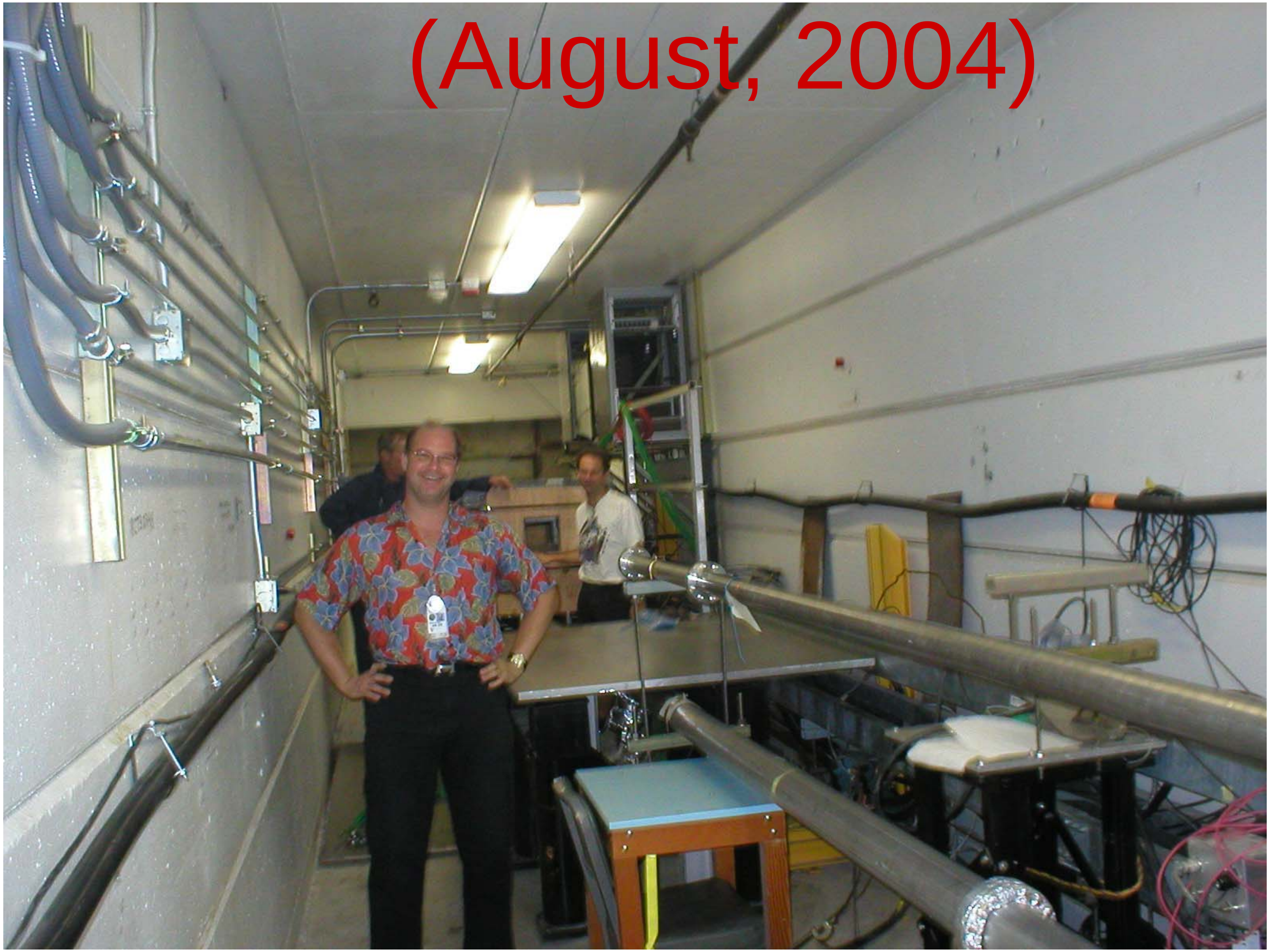
E166 Status: Undulator (Cornell U.)



E166 Status: Undulator Cornell U.



E166 Status: Det. Install. (August, 2004)



Target Radiation Damage and Power Deposition

Specific Interest in Understanding Limits of Target Material Integrity Due to Radiation Damage

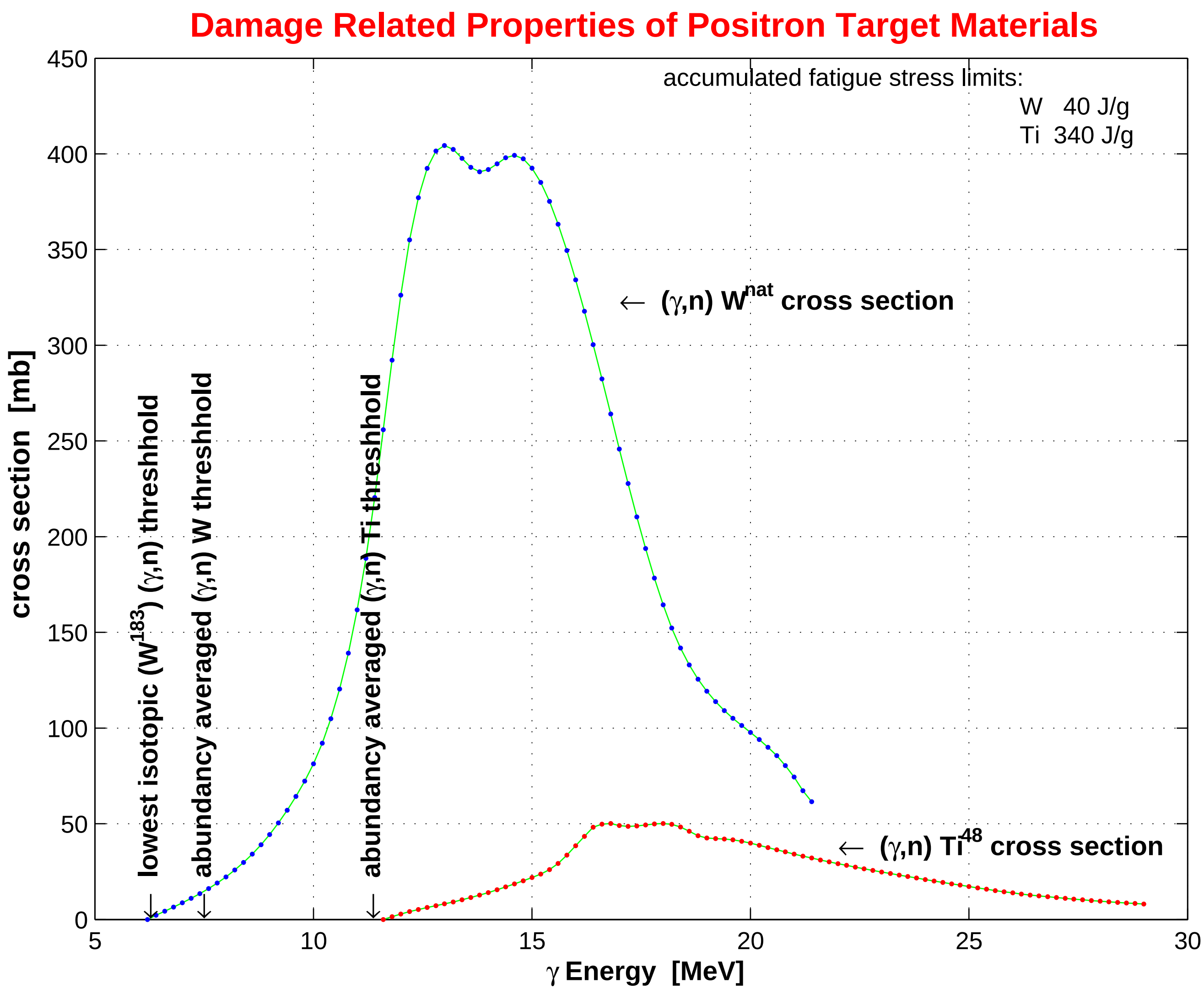
Experience with SLC WRe Target Failure and Analysis (LANL, LLNL, SLAC)

Need to Develop Similar Knowledge for other Candidate Target Materials

Require Consideration of Radiation Damage (chronic failure) as well as Peak Shock/Stress (acute failure) in Target Station Design

Also Interested in General Radiation Environment when Beam Goes Off and Is It Possible to Use a SC AMD

γ,n Cross sections



BNL Radiation Damage Tests

Radiation Damage Tests of Candidate Target Materials, BNL (photo: March, 2004)

Tensile Analysis is scheduled for November, 2004

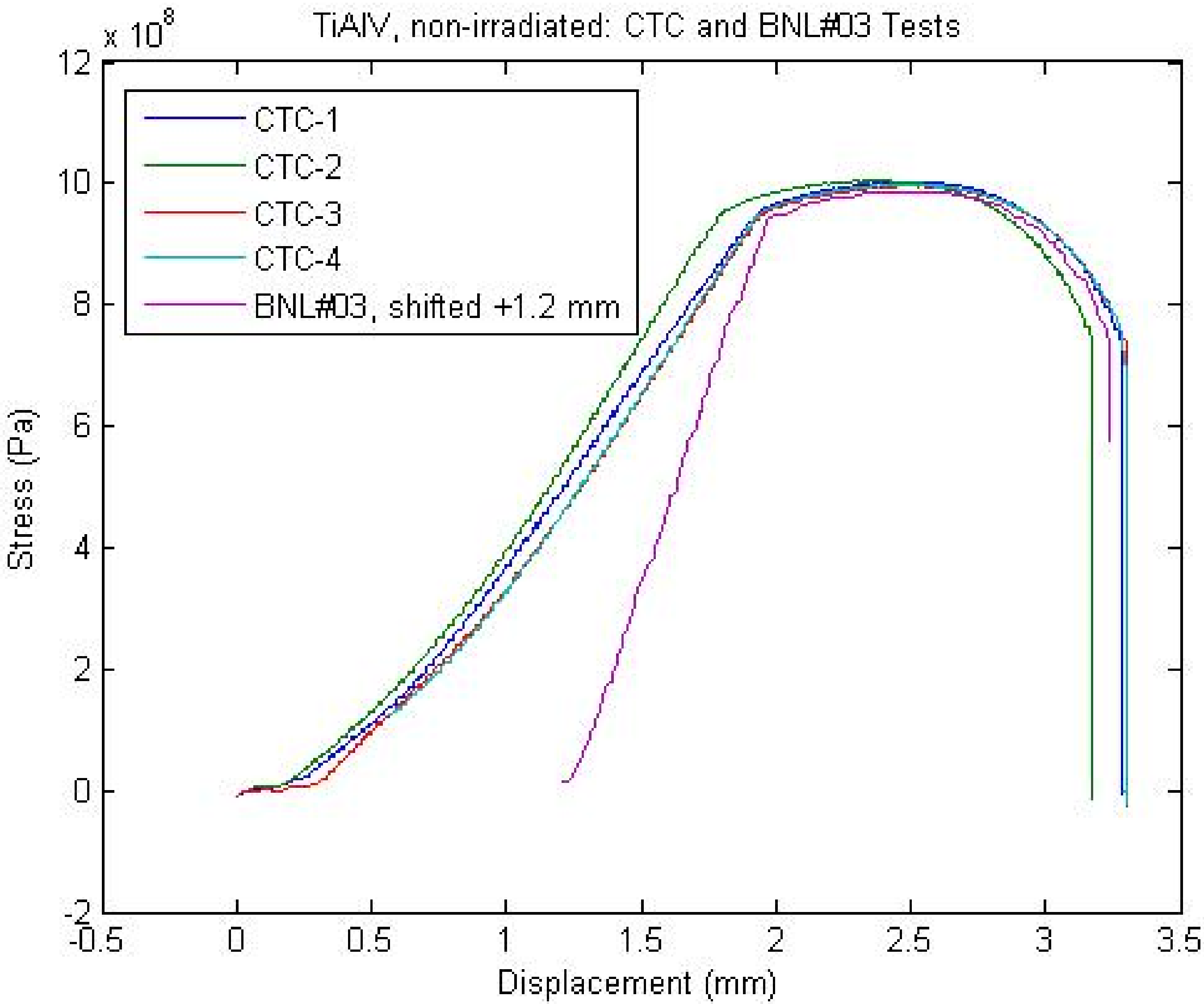
Structural Damage Simulation to Simulate Undulator Target; using tools to compare prediction with damage observed in BNL test (200 MeV p+ irradiation)

BNL/LLNL/UCB/SLAC simulations in Collaboration with the Muon Collider Collaboration

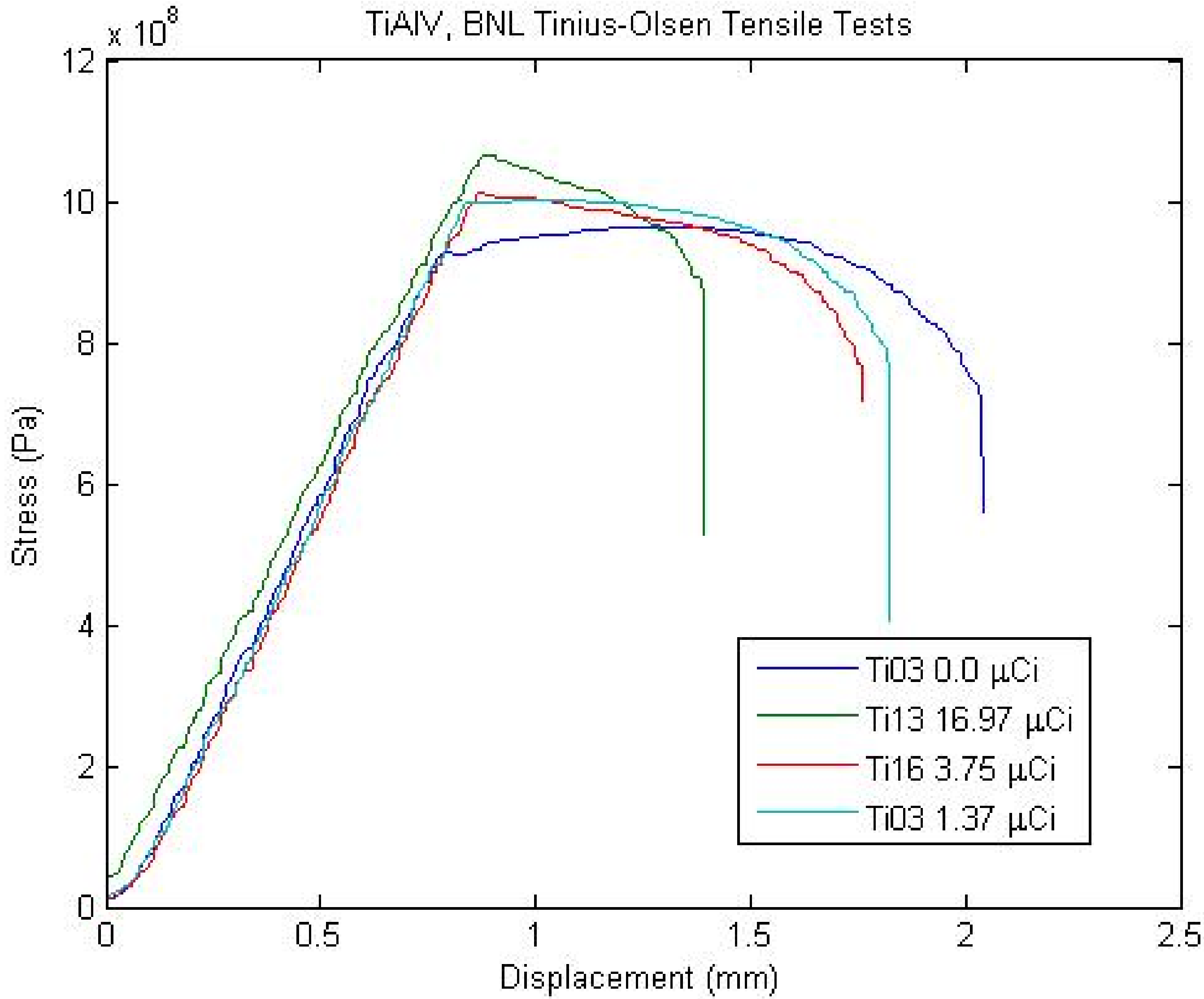
BNL Tensile Test, non-irradiated Vascomax: 11-09-04

CTC Tensile Test, Non-irradiated Samples, 11/02/04

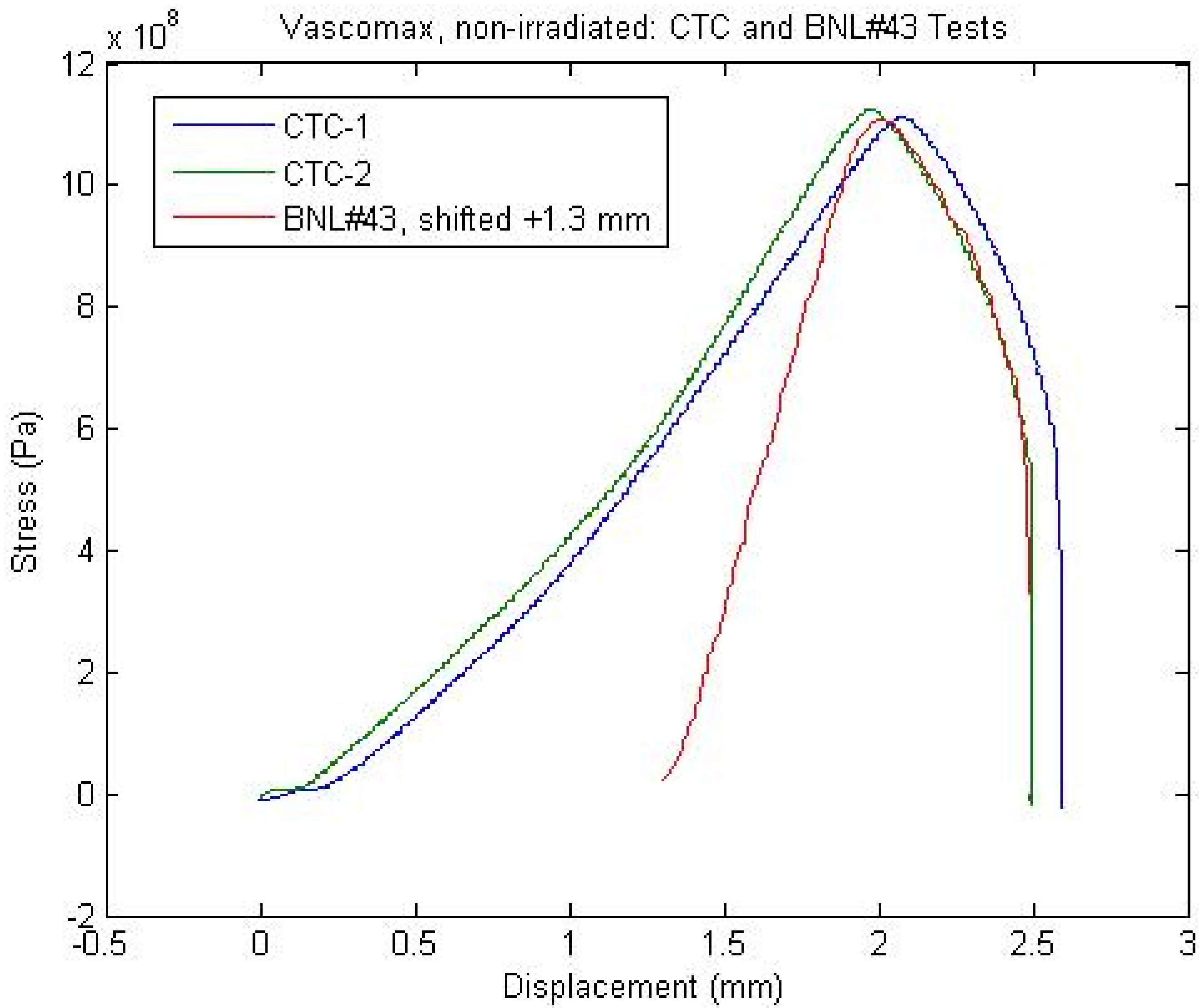
CTC, BNL Ti-Alloy Tensile Test, Non-irradiated



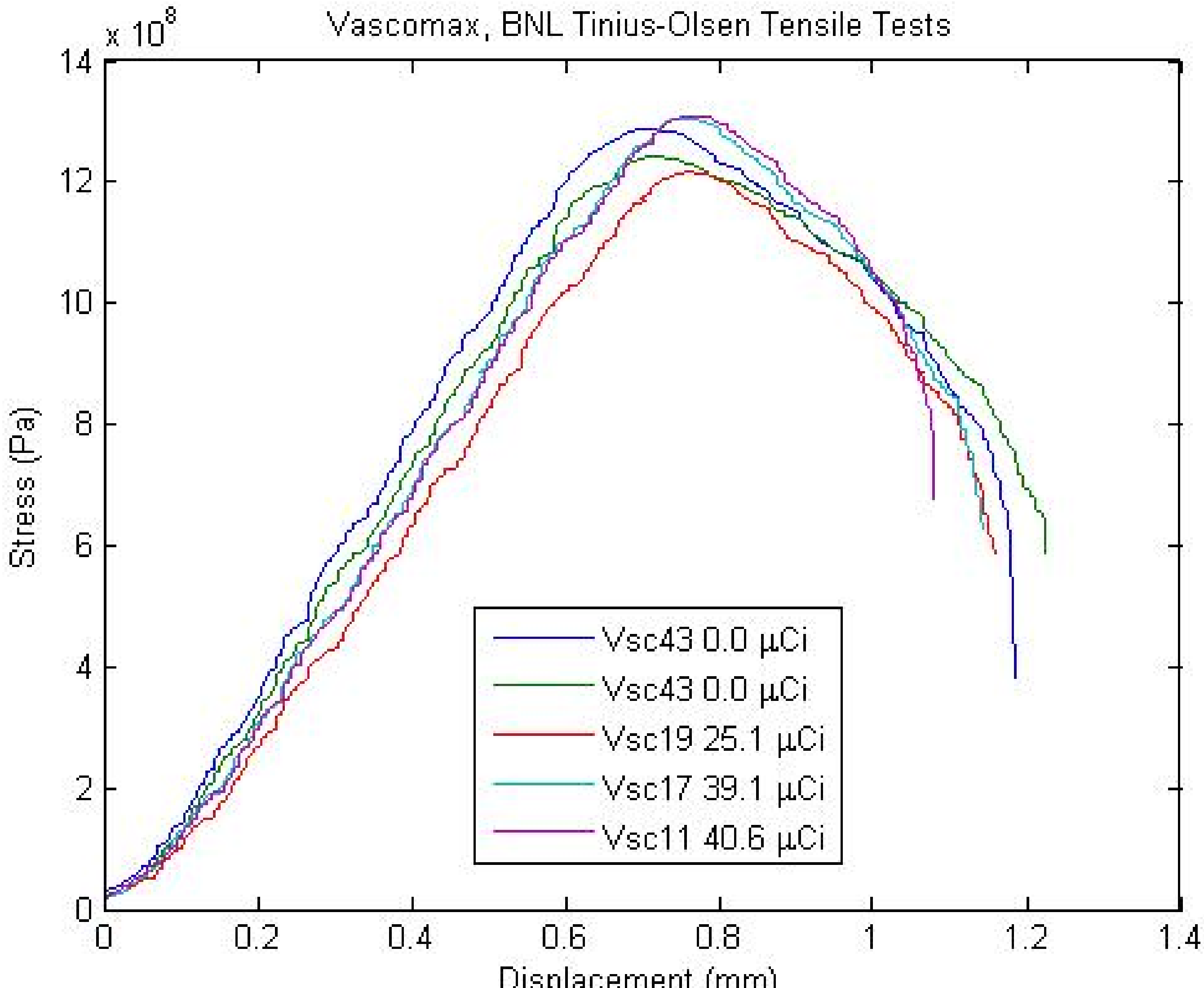
BNL Ti-Alloy Tensile Test, Irradiated



CTC, BNL Vascomax Tensile Test, Non-irradiated



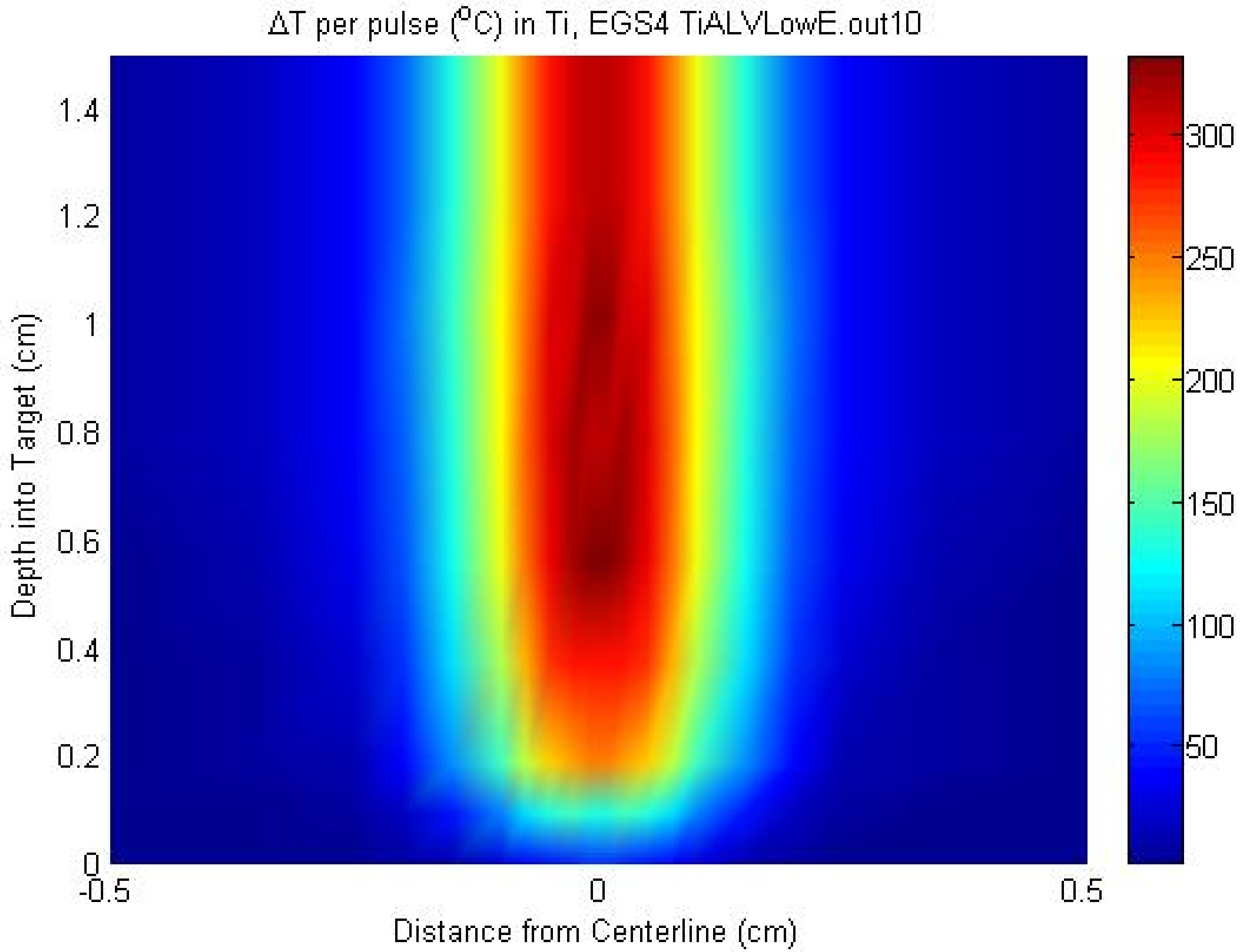
BNL Vascomax Tensile Test, Irradiated



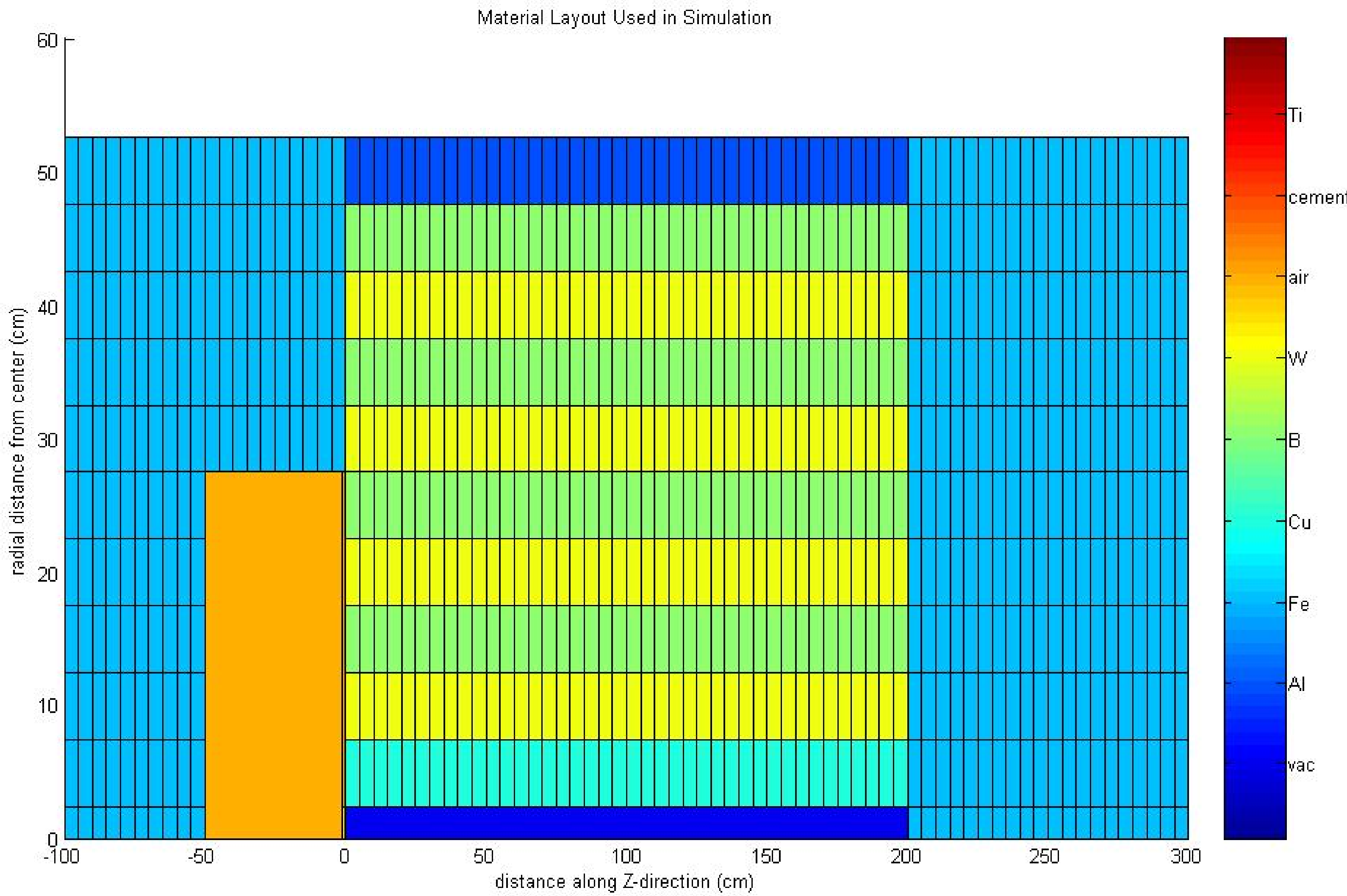
Radiation Damage Simulation: γ-TiAlV: SLAC, LLNL, UCB

International Linear Collider
at Stanford Linear Accelerator Center

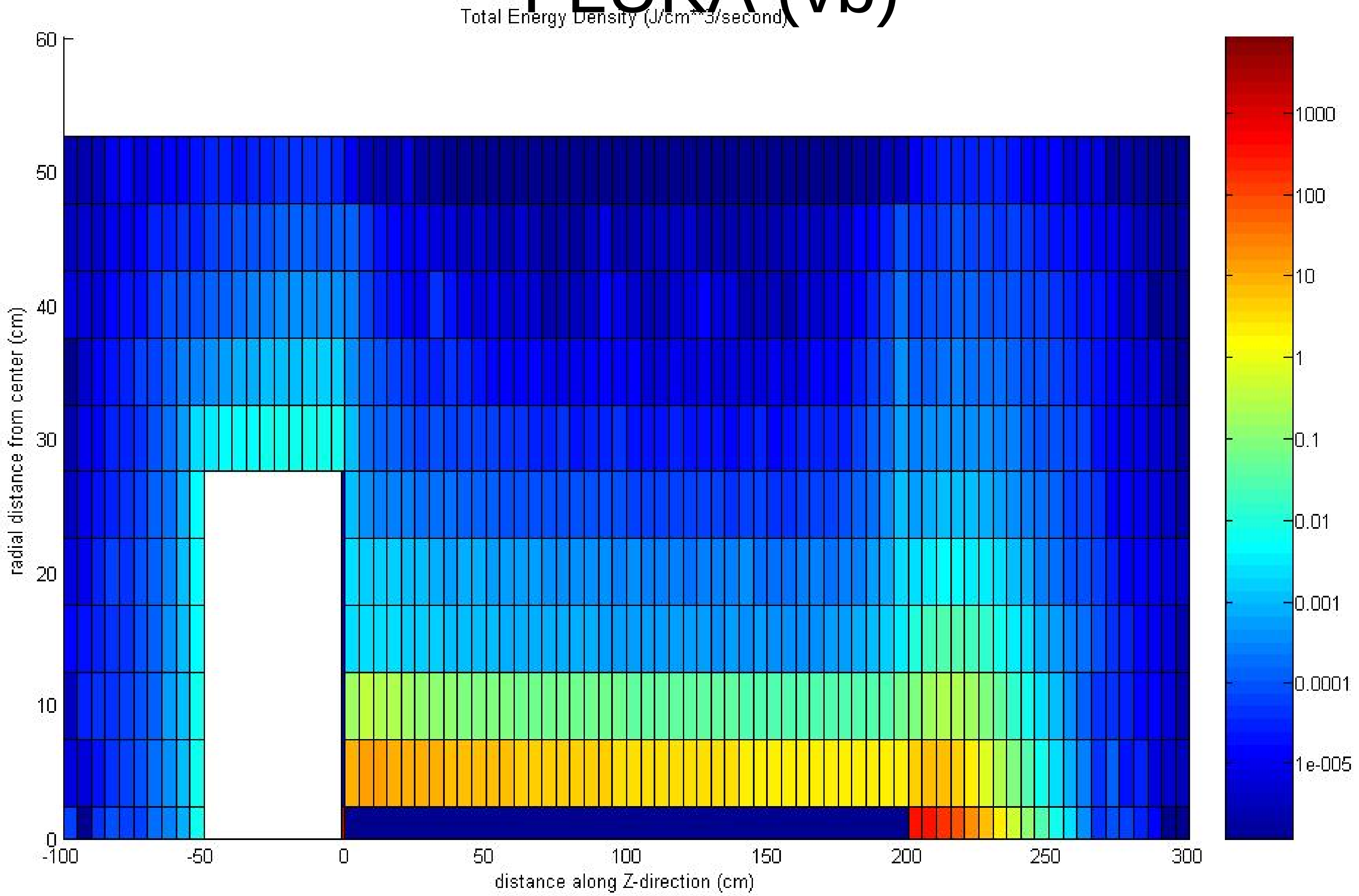
Goal is to Predict Material Properties Degradation and to Benchmark Against Empirical Data: γ-n in FLUKA, SPECTER used to estimate property changes



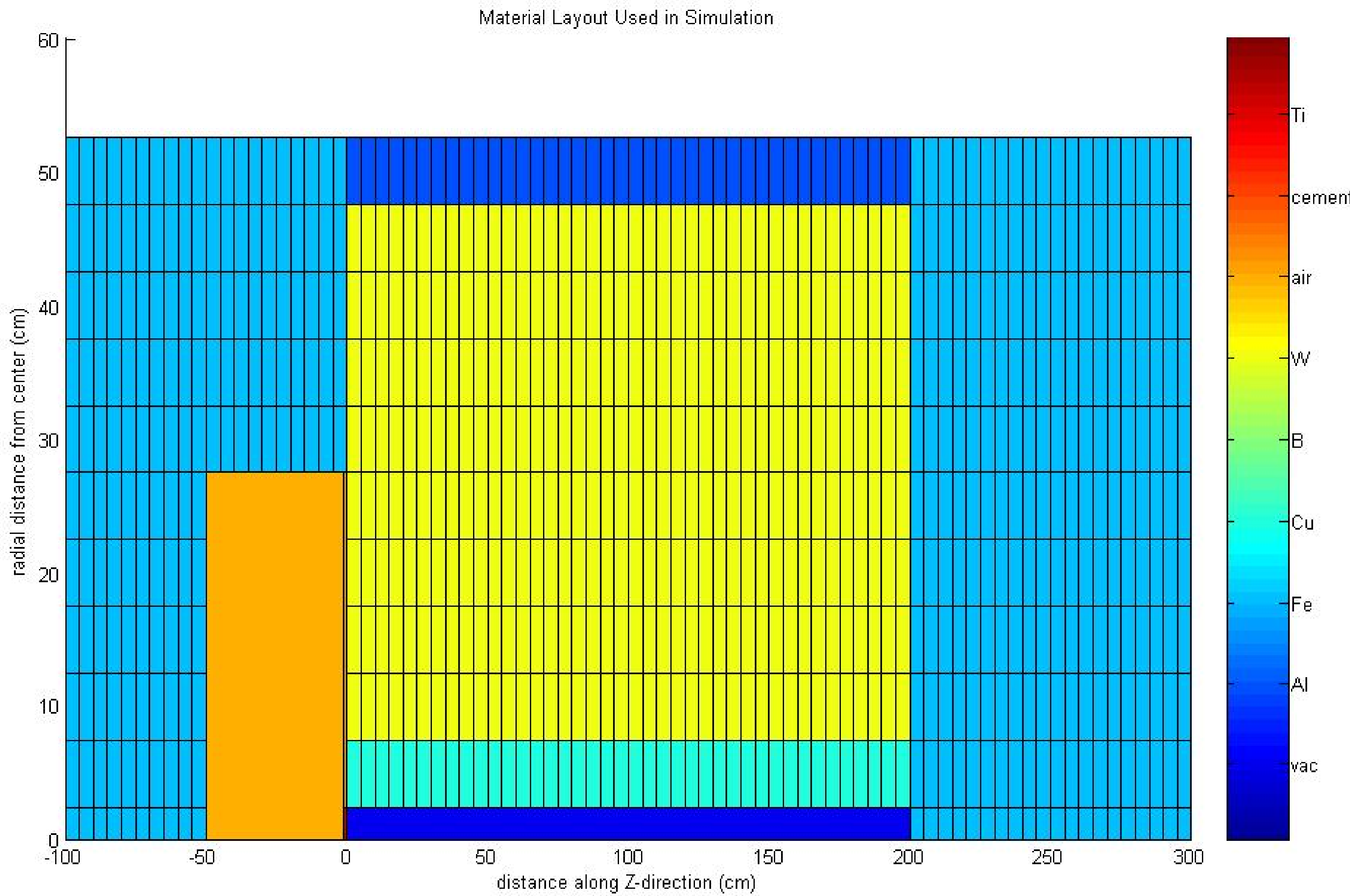
Energy Deposition, Station Geometry-Conv



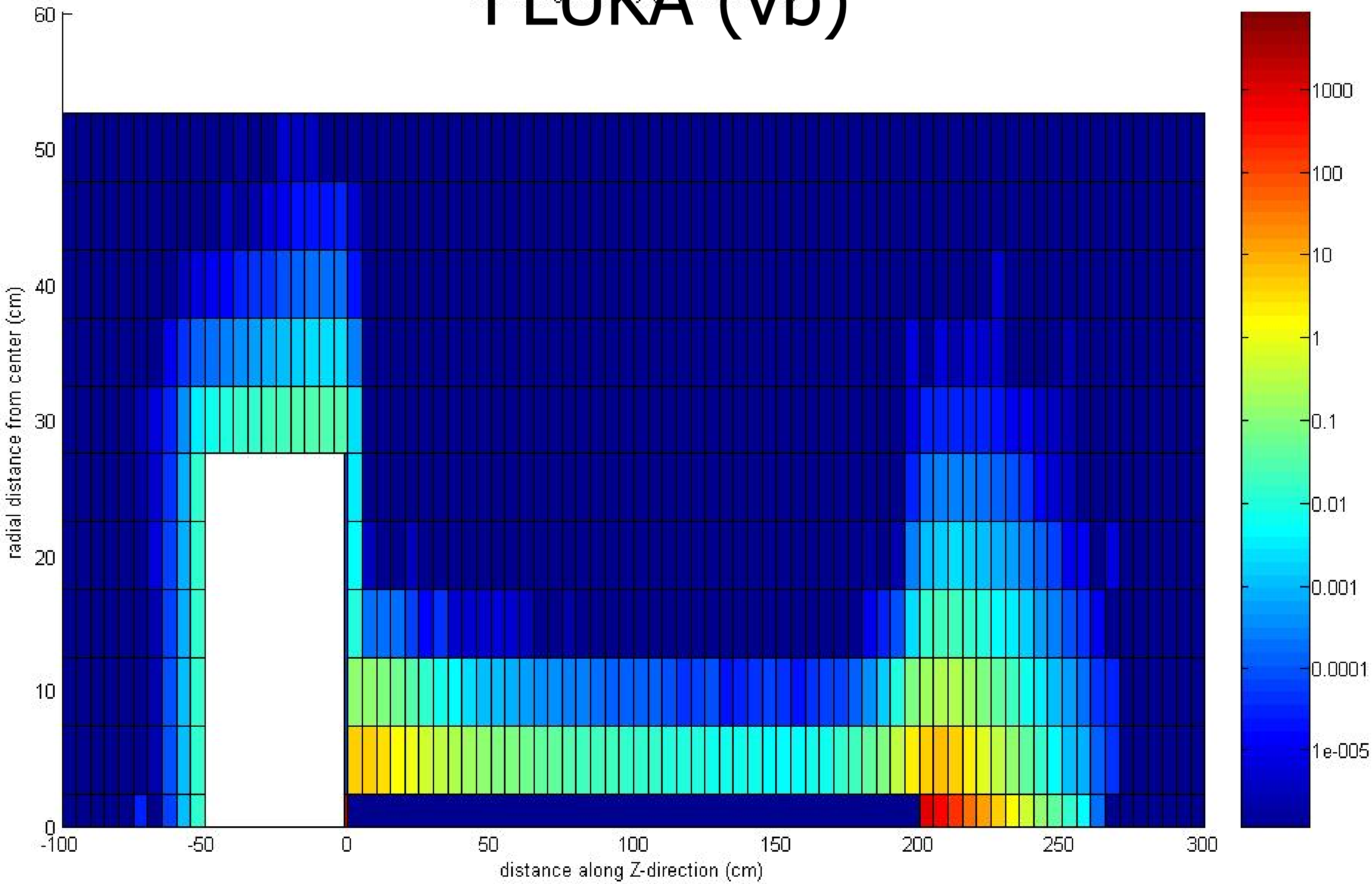
E-Depo-Conv: 280 kW Incident, 6.2 GeV e-, FLUKA (vb)



Energy Deposition, Station Geometry-Und



E-Depo-Conv: 220 kW Incident, 0-10 MeV γ, FLUKA (vb)



Topics for Study

Undulator Design

Undulator Insertion Bandpass and Machine Protection

Basic Capture Yield Calculations (AMD, rf gradient, focusing optics, capture aperture(6-D))

Energy Deposition and Stress

Radiation Damage Threshold

Candidate Target Material Selection and Testing

Average Power Removal

Target Station Layout

Removal and Replacement Scenarios

Infrastructure (remote handling, equipment shielding)

Civil Facility Specifications

Activities for a CDR

Specification of Beam Parameters

Specification of Damping Ring 6-D Acceptance (strongly urge addition of a predamping ring for increased acceptance and relaxation of e+ production systems)

Decision on Baseline Design Option: Conventional Undulator, other (is the Compton Backscattered Photon System Adaptable to the SC Design Parameters?)

Design Parameter Choice Optimization

Resolution of Availability Issues

Fall Back Scenarios

Upgrade Options

Activities for a TDR

AMD Prototype Demonstration

Capture rf Section Prototype (incl. rf power source if required)

Material Damage and Shielding Tests

Target Station Prototype

Undulator Section Prototype

Photon Collimator Design and Test as Needed

Possible US Collaborators

SLAC ILC, SLAC RP

LLNL/UCB/BNL

ORNL

Cornell

Princeton

Plus anyone else with interest, capability, support

Summary

Investigations of the Viability of a Conventional e+ source for the ILC are Underway

Undulator Based Positron Production is a viable method for LC Positron Polarization

Possibility of Reduced Radiation to Target and Surrounding Equipment

Requires a High Energy e- Drive Beam

E166 Demonstration in Progress

BNL/LLNL/SLAC/UCB TiAlV Radiation Damage Test in Progress

Need a Decision on DR acceptance (strongly encourage addition of a e+ predamping ring)

Need a Decision for CDR to Adopt or Defer this Option

Equipment needs Prototyping for TDR